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## MICTURITION AIDED BY ELECTRIC STIMULATION: A SUBACUTE STUDY

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In the previous article<sup>1)</sup>, the correlation of the site of stimulation and various stimulating parameters were studied. Based upon these observations, a subacute experiment was carried out. The result will be briefly reported and discussed here.

### METHODS AND MATERIALS

A female mongrel dog, #D-018-ES, 26.5 kg, underwent an episiotomy under pentobarbital anesthesia. This procedure, subsequently, made it easy to pass a catheter and to observe a urinary flow. The urinary bladder was exposed through a lower median incision, where the adherent peritoneum was peeled off. Bladder being inflated with 100 ml of water, six electrodes were implanted in the detrusor in two circles, i. e. in the upper third between apex and uretero-vesical junction<sup>1)</sup>. Three electrodes in one circle functions as alternating polarity. The electrode, 8 mm in diameter, is made of stainless steel, and shielded with Silastic (Dow Corning, U.S.A.) in one side. The stainless steel wire is also covered with Silastic tube. Each electrode was buried under the serosa and fixed with a fine silk suture. Three wires joined together at 10 cm away from the disk electrode. Then the tip of two wires were placed subcutaneously. The sheath of rectus muscle and skin were closed. Antibiotics were given 5 days following operation.

The subacute study was performed two weeks later under a light anesthesia with pentobarbital. Through a small skin slit, two lead wires were found and connected with a stimulator. Intravesical pressure was transmitted via a fine plastic tube, placed in the urethra, into a pressure strain gauge transducer. The respiratory

movement was monitored with a chest bellows. These two parameters were recorded on a polygraph (RM-20, Nihon Kodens). The urinary flow was studied either through a X-ray television (MTV-9, Toshiba) or a flowmeter (14F45 Mictiograph, DISA, Denmark). The fixed stimulating parameters were as follows: biphasic square pulse of 5 msec duration and frequency of 30 Hz.

### RESULTS

No urinary flow was encountered at the voltage of less than 10 volts in spite of elevated intravesical pressure (Fig. 1, A). When the voltage of more than 15 volts was applied, a satisfactory voiding was observed without any residual urine (Fig. 1, B & C). The maximum intravesical pressure was lower than that observed with 10 volts. The urinary stream was large and forceful. The maximum flow rate was 22 ml/sec at 15 volts and 30 ml/sec at 20 volts (Fig. 1, B' & C'). A variable degree of tonic spasm appeared in the lower abdomen and lower extremities.

Voiding pattern observed in TV screen was illustrated in Fig. 2, which was recorded with 35 mm films. No residual urine with six electrodes implanted in the detrusor was demonstrated in a post-voiding cystogram (Fig. 3).

### DISCUSSION

The contraction of detrusor muscle and the relaxation of perineal muscles, the external sphincter in the male, must coordinate to pass urine without an increase of urethral resistance.

The urinary bladder responded to an

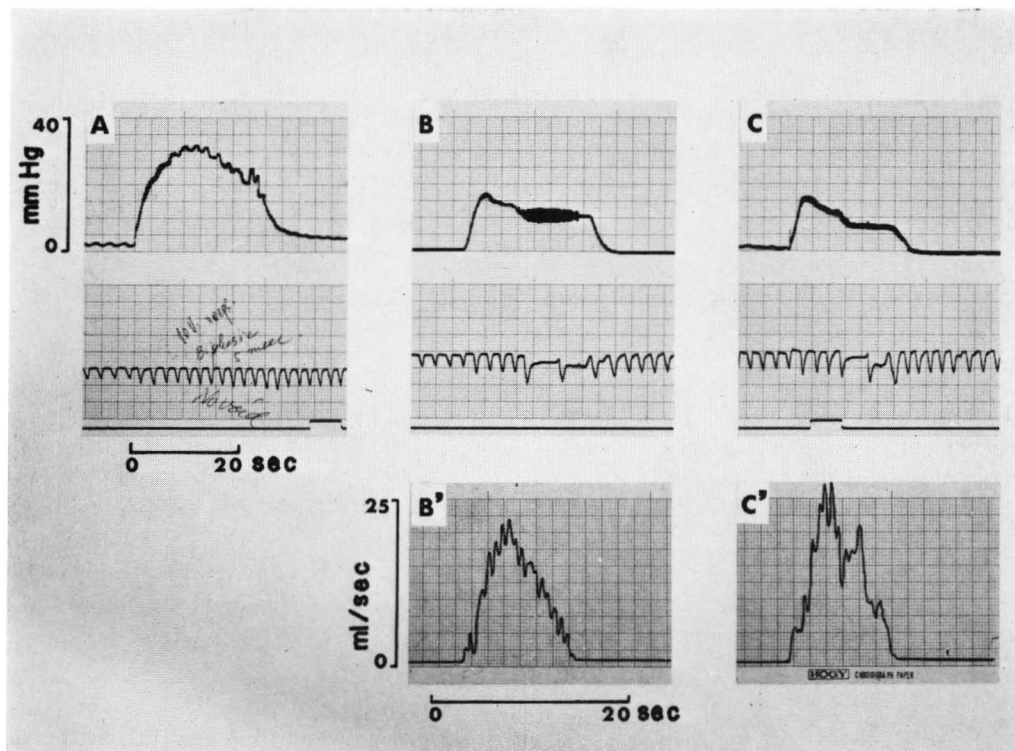


Fig. 1. Intravesical pressure (upper curve), respiratory movement (middle curve) and urinary flow rate (lower curve) are illustrated. Stimulating voltage was 10 volts in A, 15 in B and 20 in C. Note a transitory arrest of respiration in the later two which coincided with the tonic spasm in the skeletal muscle. Bladder capacity was 150 ml in each case.

electric stimulation with a strong contraction. Surprisingly, the micturition was completed with a lower intravesical pressure (Fig. 1, B & C) than that experienced in an acute study<sup>17</sup>. The coefficient of urethral resistance, reported by Susset et al.<sup>22</sup>, was found to be 0.04 R units and 0.02 R units at 15 and 20 volts respectively. These two facts indicated that the urethral resistance was negligible. Susset and Boctor<sup>30</sup> and Halverstadt<sup>43</sup> took advantage of detrusor stimulation and reported the successful trial in patients. On the other hand, the tonic spasm of skeletal muscle apparently increased in magnitude as the higher voltage was given. The prevention of current spread to the adjacent tissue still remains to be a further investigation.

The first clinical trial was performed in two patients on the operation table (Fig. 4, A & B). The bladder wall was stimulated under general anesthesia and ECG surveil-

lance prior to a retropubic prostatectomy. Stimulation was given only in the anterior wall with 4 electrodes instead of 6 for precaution. The elevation of intravesical pressure was observed with a slight clonic spasm.

When an implantation of stimulating device, now under development, is attempted, the quality of materials, i.e. durability and reliability, must be taken into consideration, which requires a long term observation.

#### SUMMARY

With six electrodes implanted for two weeks in a female dog detrusor muscle, a satisfactory voiding was obtained using 15 volts and 20 volts. No residual urine was observed and coefficient of urethral resistance was quite low. Two clinical transitory experiences were reported. Though a tonic spasm in the skeletal muscle was

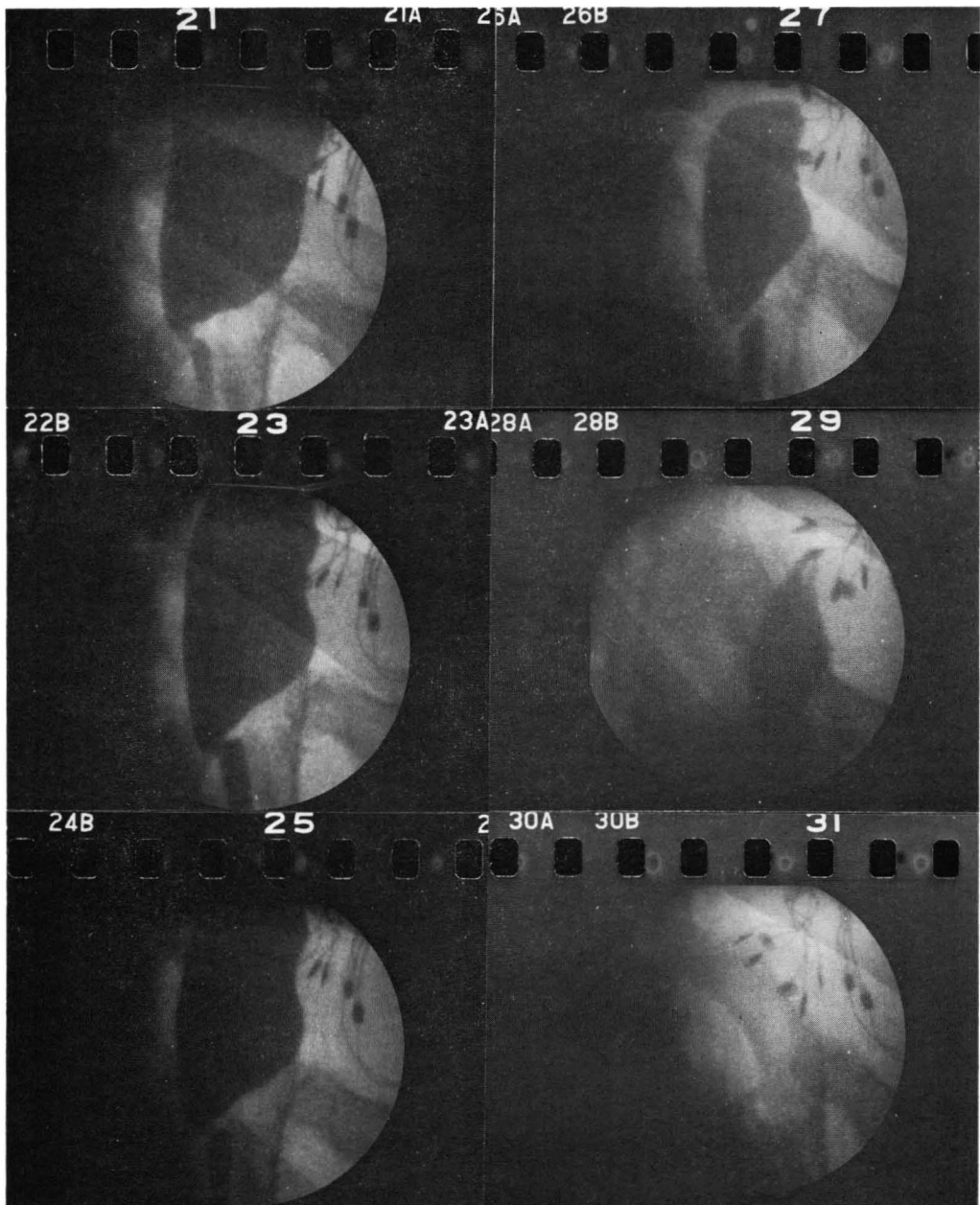


Fig. 2. Voiding proceeded in the order of film number, where the dog lay down in oblique position. Note a quite large caliber of the urethra. The interval of each shot is approximately 3 seconds.

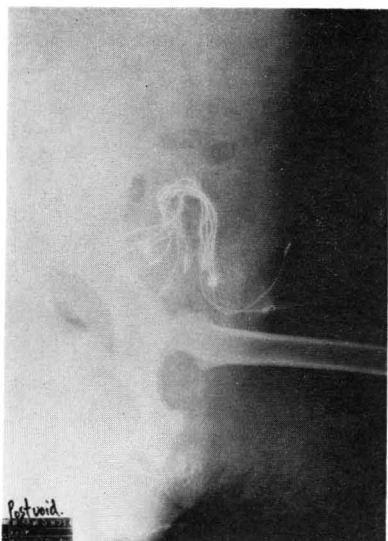


Fig. 3. Post-voiding cystogram with six electrodes implanted in the detrusor muscle. No contrast medium is left.

encountered, the direct stimulation technique at detrusor muscle worked well and seemed to be promising.

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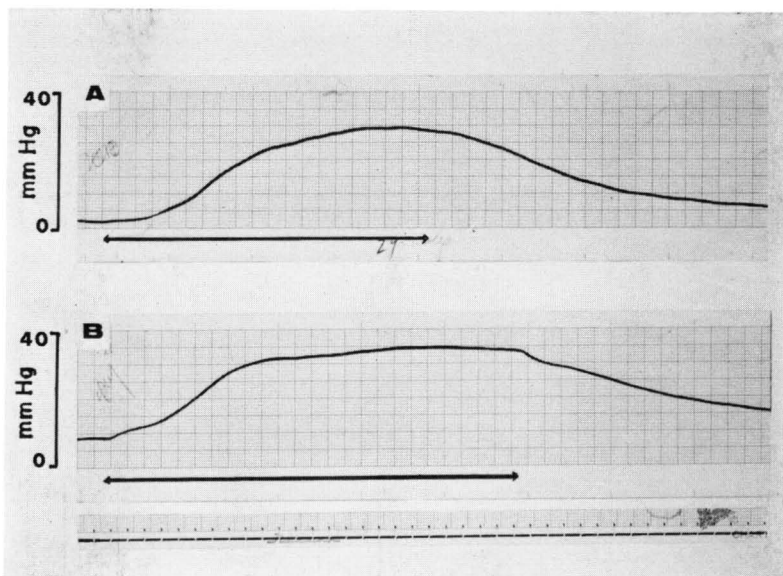


Fig. 4. Clinical trial on the operation table. The bladder was inflated with 200 ml of saline via a #20 Foley catheter placed in the urethra. A; A. Y., 73-year-old male. A biphasic square wave, pulse duration of 3 msec, 50 Hz and 20 volts. B; 77-year-old male. A biphasic square wave, pulse duration of 1 msec, 30 Hz and 25 volts. In both cases, a slight clonic spasm was observed in the lower extremities. A horizontal bar in each recording shows the period of stimulation. Time signal at the bottom indicates one second.

## 電 気 刺 激 に よ る 排 尿 : 亜 急 性 期 実 験

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## 要 約

メス雑犬の膀胱利尿筋漿膜下に6コの円板状電極を植め込み慢性期実験をおこなった。2週間後、体外にある刺激装置と連結し、排尿状態を観察した。刺激電流は2相性直角波、5 msec, 30 Hz を用い20~30秒通電した。10ボルト以下では膀胱内圧は31 mmHgまで上昇するも排尿は認められなかった。電圧を15ボルト以上にすると円滑なる排尿がおこり、残尿は認められなかった。最大排尿率は15ボルトで22 ml/sec,

20ボルトで30 ml/sec を記録し、尿道抵抗係数は小さかった。またレ線テレビジョンを用いて排尿運動を観察した。なお2例の臨床経験を簡単に報告した。すなわち4コの刺激電極を手術前短時間膀胱前壁に装着し、膀胱内圧の上昇を認めた。

刺激電圧が高くなるとともに、骨格筋の強直性痙攣が増強した。これは将来解決すべき問題点である。膀胱頂部近くの利尿筋直接刺激は有効性の高い方法と考えられる。